REMARKS

Claims 1-9 and 29-47 are pending in the application, of which claims 1, 29, 46, and 47 are independent. Favorable reconsideration and further examination are respectfully requested.

The Examiner rejected claims 1 and 29 under 35 U.S.C. § 112(2) as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. As amended, the body of claims 1 and 29 refer to the dielectric of the preamble, and the body of claim 1 refers to the integrated circuit of the preamble. For at least the foregoing reason, claims 1 and 29 particularly point out and distinctly claim the subject matter which applicant regards as the invention.

The Examiner rejected claims 4 and 32 under 35 U.S.C. § 112(2) as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The Examiner contends that

> ...it is unclear what "a predicted Kanaya-Okayama range of electrons" (emphasis added) is, or how one would determine this predicted quantity. The examiner notes that on page 7, "the Kanaya-Okayama range" is defined as $r = (2.76x10^{-2}AE_0^{1.67})/\rho Z^{0.89}$, however as Z appears to be said [sic] to be the atomic number of accelerated electrons, this formula would appear to be meaningless, because electrons do not have an atomic number, as they are not atoms! The atomic mass (A) of an electron can be input into the formula, but what the density (ρ) of an electron would be is unclear, although it could refer to electron beam current density. The examiner suspects that the disclosure on page 7 is defective, insufficiently describing the variables of the formula, however the result of this is that one cannot use the disclosure to figure out or predict claim values, thus making the meaning of the claimed predicted range unclear (and insufficiently enabled in the specification, see below). It is noted that the abstract of the article by Kanaya et al. is discussing an atomic model giving the potential between electrons & atoms with a formula related thereto, with the article's page 44 discussing the formula for scattering cross section, where Z is the atomic number of the target, suggesting to the examiner that the description of A, Z & maybe ρ as

> defined in applicant's specification is incorrect or incomplete, however while the cited article might possibly enable applicant to correct the above confusion (if so applicant should provide careful citations of support with reasoning on why the original specification necessitates any changes), the actual disclosure in the present specification is not clear, thus making the claims unclear. Also, in order to get a meaningful number out of the empirical formula, one must know what units to employ for the variables, and while the atomic mass (A) might be assumed to be atomic weight as listed on a periodic table, and the atomic number (Z) is a unitless [sic] value, one still needs to know the units for density & acceleration voltage for which the disclosed empirical formula was designed. A further potential problem, assuming A, Z & ρ are supposed to describe characteristics of the CDO film, is that this film has a molecular structure having at least two different types of atoms (C & O, others undefined), hence does not have a single atomic number that could be input into the formula, such that it would be unclear whether one is supposed to calculate "r" for each type of atom present in the molecular structure, or the proportional average of their properties, etc., & if calculated individually, whether all such calculations or merely one need to fit the claimed criteria, or what.... As presently written, claims 4 & 32 are impossible to evaluate meaningfully with respect to the prior art, except possibly in terms of intended effect discussed on lines 13-16 of page 7. [Id., Pages 3-4]

Applicants disagree. The reference provided in the application for the Kanaya-Okayama range (See Paragraph [0016] in the published application, "Kanaya Reference") provides the proper units for the quantities in the formula in Eq. (1) in the application. (i.e., ρ is in units of g/cm^3, Z is dimensionless, A is in g, N is in cm^{-3}, and E_0 is in eV.) Further, one skilled in the art would understand that the atomic mass, atomic number, and density in that formula refer to the target and not the electron beam. Still further, one skilled in the art would also understand that a formula such as Eq. (1) for the Kanaya-Okayama range is valid for a polyatomic target as well as a monatomic target, as differential scattering cross section for energy transfer between an electron and a target material [See Kanaya Reference, Equation (6)] is a weighted average of the individual differential scattering cross sections of each component monatomic material. For at least the foregoing reason, claims 4 and 32 are believed to be sufficiently definite.

The Examiner rejected claims 6, 7, 34 and 35 under 35 U.S.C. § 112(2) as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The Examiner contends that

> In claims 6 & 34, the limitation concerning the dielectric film being an interlevel dielectric is noted to only referrer [sic] to the preamble, such that it is unclear how the claimed interlevel dielectric film relates to the CDO film. Furthermore, with respect to claims 6-7 & 34-35, the intent or intended meaning of "preparing a damascene structure in the CDO film" & "filling the damascene structure with a metal" is ambiguous or unclear, as a damascene structure would by a normal definition be a structure that is inlaid with metal, hence if there is already an inlay of metal, which would appear to be required by the "preparing..." limitation, it is indeterminable and unknown what is being filled with metal after the damascene structure has already been formed (i.e. prepared). It is noted that on page 1, lines 17-21 of the specification, there is discussion of copper damascene structures, which clearly indicates that "damascene structures" should be referring to metal structures, with figure 7, referred to on page 7, lines 17-18 illustrating a process for forming such structures (750), although the discussion of figure 7 on page 14 appears to use similar imprecise & confusing use of "damascene structure" as present in the claims, such that from the specification as a whole, clear meaning for these claim limitations as written is not present. [Office Action, Page 4]

Applicants disagree. The bodies of claims 1 and 29 refer to the dielectric. Further, regarding claims 6-7 and 34-35, one skilled in the art would understand that a damascene structure is a patterned hole in a dielectric, and one skilled in the art would also know that such holes are generally filled with metal. For at least the foregoing reason, claims 6-7 and 34-35 are believed to be sufficiently definite.

The Examiner rejected claims 8 and 36 under 35 U.S.C. § 112(2) as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The Examiner contends that

> Claims 8 & 36 are unclear as what constitutes "excess metal", as excess metal has not been defined, nor for the claims as written is there necessarily any excess metal present, thus it is unclear from where if it all any metal is being removed. [Office Action, Page 4]

Applicants have amended claims 8 and 36 to recite the following: "wherein excess metal is metal that overfills the damascene structure and spills onto the dielectric surface." One skilled in the art would understand that this excess metal may be removed via a chemical-mechanical polishing (CMP). For at least the foregoing reason, claims 8 and 36 are believed to be sufficiently definite.

The Examiner rejected claims 4 and 32 under 35 U.S.C. § 112(1) as failing to comply with the enablement requirement. Applicants have shown above that one skilled in the art would understand how to obtain the Kanaya-Okayama range as described in Equation (1) of the application. For at least the foregoing reason, claims 4 and 32 contain subject matter that enables one skilled in the art to make and/or use the invention.

The Examiner rejected claims 1-3, 6-9, 29-31, and 34-37 under 35 U.S.C. § 102(e) are being anticipated by U.S. Patent No. 6,746,969 ("Shimada"). As amended, claims 1 and 29 recite a method of forming a dielectric film, which comprises forming a carbon doped oxide (CDO) film on a substrate and treating the CDO film with an electron beam, where the CDO film is not heated.

Shimada is not understood to disclose or to suggest at least the foregoing features of claims 1 and 29. In this regard, Shimada discloses treating a semiconductor substrate with an electron beam while the semiconductor substrate is heated. (See Shimada, Column 4, Lines 24-

31; Column 7, Lines 7-10; Column 13, Line 24-27.) For at least the foregoing reason, claims 1 and 29 are believed to be patentable over Shimada.

The Examiner rejected claims 1-9 and 29-37[1] under 35 U.S.C. § 102(e) are being anticipated by U.S. Patent No 6,605,549 ("Leu"). As amended, claims 1 and 29 recite a method of forming a dielectric film, which includes forming a carbon doped oxide (CDO) film on a substrate and treating the CDO film with an electron beam such that an exposure of the CDO film with the electron beam delivers a dose between about 3000 $\mu C/cm^2$ to about 5000 $\mu C/cm^2$.

Leu is not understood to disclose or to suggest at least the foregoing features of claims 1 and 29. In this regard, Leu discloses exposing a formed dielectric layer on a substrate in an electron beam chamber to a dose of about 10 $\mu C/cm^2$ to about 500 $\mu C/cm^2$. (Leu, Column 5, Lines 49-53.) This range is not in between about 3000 $\mu C/cm^2$ to about 5000 $\mu C/cm^2$, and accordingly, claims 1 and 29 are believed to be patentable over Leu.

The Examiner rejected claims 1-3 and 29-31 under 35 U.S.C. § 102(b) are being anticipated by U.S. Patent No. 6,132,814 ("Livesay"). As amended, claims 1 and 29 recite a method of forming a dielectric film, which comprises forming a carbon doped oxide (CDO) film on a substrate and treating the CDO film with an electron beam, where the CDO film is not heated.

Livesay is not understood to disclose or to suggest at least the foregoing features of claims 1 and 29. In this regard, Livesay discloses treating a substrate with an electron beam while the semiconductor substrate is heated to between 150°C to 250°C. (Livesay, Column 7,

[1] The Examiner did not specify which claims were rejected in the Office Action. We therefore assume that all prior claims were rejected. This does not change the nature of our argument.

Lines 11-12.). Claims 1 and 29, on the other hand, specifically recite the CDO film being unheated. For at least the foregoing reason, claims 1 and 29 are believed to be patentable over Livesay.

The Examiner rejected claims 1-3 and 29-31 under 35 U.S.C. § 102(e) are being anticipated by U.S. Patent No. 6,936,551 ("Moghadam"). As amended, claims 1 and 29 recite a method of forming a dielectric film, which comprises forming a carbon doped oxide (CDO) film on a substrate and treating the CDO film with an electron beam such that the CDO film is unheated.

Moghadam is not understood to disclose or to suggest at least the foregoing features of claims 1 and 29. In this regard, Moghadam uses either an infrared lamp or the electron beam itself to heat his CDO film. More specifically:

> In accordance with further embodiments of the present invention, infrared lamps 36 are not used to heat wafer 27. In accordance with such embodiments, the electron beam is used to both irradiate and heat wafer 27. In this case the product of the beam current and the beam voltage (power=current*voltage) is greater than the power radiated away by the wafer, and therefore wafer 27 is heated by the electron beam. [Moghadam, Column 7, Lines 57-64]

Moghadam is clearly treating his CDO film at a specific electron beam power that forces the electron beam to heat the CDO film relative to his non-reactive gas in his electron beam chamber, as opposed to leaving the CDO film unheated as required by claims 1 and 29. For at least the foregoing reason, claims 1 and 29 are believed to be patentable over Moghadam.

The Examiner rejected claims 1 and 29 under 35 U.S.C. § 102(b) as being anticipated by Japanese Patent Application No. 62-132326 ("Iwamoto"). As amended, claims 1 and 29 recite a method of forming a dielectric film, which comprises forming a carbon doped oxide (CDO) film

on a substrate and treating the CDO film with an electron beam such that the CDO film is not heated, and that the exposure of the CDO film with the electron beam delivers a dose between about 3000 $\mu C/cm^2$ to about 5000 $\mu C/cm^2$

Iwamoto is not understood to disclose or suggest at least the foregoing features of claims 1 and 29. In this regard, Iwamoto discloses a silicon organic oxide compound that can be patterned via electron beams. Nowhere is Iwamoto understood to disclose a temperature of his CDO film during exposure to his electron beams. Nor does Iwamoto disclose a range of doses for his electron beams during the course of patterning his silicon organic oxide compound. For at least the foregoing reasons, claims 1 and 29 are believed to be patentable over Iwamoto.

The Examiner rejected claims 4 and 32 under 35 U.S.C. § 103(a) are being unpatentable over Shimada or Livesay or Leu or Moghadam as applied to claims 1-9 and 29-37 as set forth above, and further in view of U.S. Patent No. 4,027,052 ("Thompson"). None of Shimada, Livesay, Leu, and Moghadam disclose or suggest the matter in claims 4 and 32. Thompson fails to cure the infirmities of Shimada, Livesay, Leu, and Moghadam. While Thompson does supply a relationship between the energy of an electron beam and a film thickness, Thompson's purpose is in "...cross-link[ing] polymeric material at the substrate interface...Optimum conditions for cross-linking are based on the desire to produce gellation ***at the interface***." [Thompson, Column 6, Lines 64-69, emphasis added] Thus, one skilled in the art would recognize that Thompson's relationship between the energy of his electron beam and the thickness of his film whose ***surface*** cross-linking was sought could not be extrapolated to a range such as that predicted by the Kanaya-Okayama range. Moreover, the Kanaya-Okayama range depends on the atomic number

and mass of the target, as well as the electron beam energy and the target density; therefore, the Kanaya-Okayama range formula allows for evaluation of the range-energy dependence for different materials, while Thompson's formula is only valid for his polyvinyl ferrocene polymer. None of Shimada, Livesay, Leu, Moghadam, and Thompson, then, disclose or suggest the matter in claims 4 and 32. For at least the foregoing reasons, claims 4 and 32 are patentable over Shimada or Livesay or Leu or Moghadam as applied to claims 1-9 and 29-37 as set forth above, and further in view of Thompson.

The Examiner rejected claims 1-9 and 29-37 on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-3 of U.S. Patent No. 6,417,098, or 1-12 of U.S. Patent No. 6,432,811, or 1-18 of U.S. Patent No. 6,703,324, or 1-11 of U.S. Patent No. 6,984,518, in view of Iwamoto, or Shimada, or Livesay, or Leu, or Moghadam, optionally in view of Thompson for claims 4 and 32. Applicants request that this rejection be held in abeyance until allowable subject matter is indicated.

Each of the dependent claims is also believed to define patentable features of the invention. Each dependent claim partakes of the novelty of its corresponding independent claim and, as such, has not been discussed specifically herein.

It is believed that all of the pending claims have been addressed. However, the absence of a reply to a specific rejection, issue or comment does not signify agreement with or concession of that rejection, issue or comment. In addition, because the arguments made above may not be exhaustive, there may be reasons for patentability of any or all pending claims (or other claims) that have not been expressed. Finally, nothing in this paper should be construed as

an intent to concede any issue with regard to any claim, except as specifically stated in this paper, and the amendment of any claim does not necessarily signify concession of unpatentability of the claim prior to its amendment.

In view of the foregoing amendments and remarks, Applicant respectfully submits that the application is in condition for allowance, and such action is respectfully requested at the Examiner's earliest convenience.

Applicants' undersigned attorney can be reached at the address shown below. All telephone calls should be directed to the undersigned at 617-521-7896.

Please apply any fees or credits due in this case, which are not already covered by check, to Deposit Account 06-1050 referencing Attorney Docket No. 10559-586003

Respectfully submitted,

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Paul Pysher
Reg. No. 40,780

Attorneys for Intel Corporation
Fish & Richardson P.C.
225 Franklin Street
Boston, MA 02110
Telephone: (617) 542-5070
Facsimile: (617) 542-8906